POWER CONTROL IN A COMMUNICATIONS SYSTEM

Field of the Invention

[0001] The present invention pertains to power control in a communications system such as a communications satellite system. More particularly, the present invention pertains to control of the power distribution among downlink beams in a multiple beam communications satellite utilizing linearized traveling wavetube amplifiers (TWTAs).

Background of the Invention

[0002] Conventional communications satellites, such as transponding satellites, which utilize a non-linear power amplifier in the transmitter, operate that amplifier at or near saturation where the non-linear power amplifier is most efficient. Using power control with such a non-linear amplifier results in an unacceptable loss in efficiency. To overcome this, such communications satellites generally use linearized traveling wave tube amplifiers (TWTAs). To assure adequate reception of the downlinked signals from the satellite, the TWTAs generally have the same power levels, and the satellites generally provide the same power to each TWTA. However, uniform power levels are not necessarily needed for all of the downlink beams.

[0003] Further, the TWTAs are frequently oversized to compensate for attenuation, for example due to rain or other inclement conditions. The power is then reduced when there is no rain or other attenuation-causing condition. The satellites generally get their power from solar cells or other sources carried on

the satellite. Making excess power available thus requires excess solar cells, which results in increased weight on the satellite. This not only is costly in providing the additional solar cells, but also costly by making launching of the satellite into orbit more expensive.

Summary of the Invention

[0004] The present invention pertains to a communications system including a multi-transmitter communications station capable of controlling the power to transmitters in the communications station, and to a method of controlling the power to transmitters in such a communications station, to a storage medium having stored thereon instructions for controlling the power to transmitters in such a communications satellite.

[0005] In accordance with the method of the present invention, the power being consumed by each of the transmitters in the communications station is determined, and a desired power setting is determined for each of the transmitters. The power being consumed is compared with the desired power settings to determine whether the present power settings are proper. If the present power settings are not proper, then it is determined whether the power needed for the desired power settings is available. If so, then the power settings are adjusted to provide the desired power settings. If the power needed to provide the desired power settings is not available, then the load priorities of the transmitters are determined, and if there is sufficient power to provide power for

the determined load priorities, the power settings are adjusted to provide power based on the load priorities.

[0006] A storage medium in accordance with the present inventions stores instructions for controlling the power to the transmitters in a communications satellite in accordance with this method.

[0007] A communications station in accordance with the present invention includes a plurality of variable gain amplifiers for amplifying respective input signals to provide intermediate signals; a plurality of high gain amplifiers for amplifying the intermediate signals from the variable gain amplifiers to provide output signals; a plurality of transmitting antennae for transmitting the output signals from the high gain amplifiers to a plurality of receiving stations; a plurality of monitoring power supplies for providing voltages to the high gain amplifiers and for monitoring the current in each of the high gain amplifiers, permitting determination of the power provided to the output signals by the high gain amplifiers; and a power profile processor responsive to a desired power setting signal from one of the receiving stations for providing a gain signal to the one of the valuable gain amplifiers associated with the one of the receiving stations to adjust the gain of the one of the variable gain amplifiers so as to adjust the power provided to the output signal of the high gain amplifier associated with the one of the variable gain amplifiers.

[0008] A communications system in accordance with the present invention includes a signal source for providing a plurality of input signals; a plurality of signal receiving stations; and a communications station of the above type.

Brief Description of the Drawings

[0009] These and other aspects and advantages of the present invention are more apparent then the following detailed description and claims, particularly when considered in conjunction with the accompanying drawings. In the drawings:

[0010] Figure 1 is a schematic representation of a preferred embodiment of a communications system operating in accordance with the present invention;

[0011] Figure 2 is a block diagram of a preferred embodiment of a communications station in accordance with the present invention;

[0012] Figure 3 is a flowchart of a preferred embodiment of a method of controlling the power to transmitters in a multi-transmitter communications station in accordance with the present invention; and

[0013] Each of Figure 4 and Figure 5 is a flowchart of an embodiment of a method of determining a desired power setting for a TWTA in accordance with the present invention.

Detailed Description of Preferred Embodiments

[0014] Figure 1 is a schematic representation of a preferred embodiment of a communications system operating in accordance with the present invention. A satellite 10 is operating in an earth orbit above the surface of the earth 12. A plurality of ground stations 14-1, 14-2, 14-3...14-n are capable of communication through satellite 10. Thus, for example, ground station 14-1 might transmit a

signal including a plurality of messages to satellite 10. Satellite 10 processes these messages and relays separate messages to appropriate ones of the ground stations 14-2, 14-3...14-n, as well as to other ground stations. Likewise, any of ground stations 14-2, 14-3...14-n might transmit a signal to satellite 10 with messages that are relayed to other ground stations.

[0015] Figure 2 is a block diagram of a communications station such as might be provided in satellite 10 to receive the messages from ground stations 14-1, process those messages, and relay them to ground stations 14-2, 14-3...14-n. The communications station includes a receiving antenna 18 which receives the messages from ground station 14-1 and applies the several messages to a demultiplexor 20 which separates the several messages. The several messages are applied through respective low noise amplifiers 22-1, 22-2...22-n to a signal processing and switching system 24. Signal processing and switching system 24 provides necessary processing for the signals, including for example filtering, power combining, and cross beam switching. From signal processing and switching system 24, the signals are applied through respective variable gain amplifiers 26-1, 26-2...26-n to respective linearized TWTAs 28-1, 28-2...28-n which apply the signals to respective transmitting antennas 30-1, 30-2...30-n for transmission to the respective receiving grounds stations 14-1, 14-2...14-n.

[0016] Power profile processor 32 receives signals on a command and control channel 34 from a controlling ground station and provides gain control signals to the respective variable gain amplifiers 26-1, 26-2...26-n. Respective monitoring power supplies or electronic power converters 36-1, 36-2...36-n provide voltages

to the respective TWTAs 28-1, 28-2...28-n and monitor the current drawn by the respective TWTAs, enabling the electronic power converters to provide power profile processor 32 with readings of the power consumed by the respective TWTAs.

[0017] Figure 3 is a flowchart of a preferred embodiment of a method of controlling the power to transmitters in a multi-transmitter communications station in accordance with the present invention. The method starts in step S1. In step S2, power profile processor 32 determines the power consumed by a TWTA, for example TWTA 28-1. This determination is based on the voltage being supplied to the TWTA by its electronic power converter 36-1 and the current flowing in the TWTA as monitored by the electronic power converter 36-1. In step S3, power profile processor 32 determines the desired power setting based on signals received on command and control channel 34 from the ground station. In step S4, power profile processor compares the power consumed with the desired power setting to determine whether the present power setting is proper. If so, the method returns to step S2. If step S4 determines that the present power setting is not proper, then in step S5 power profile processor determines the amount of power available, and in step S6 power profile processor determines whether there is sufficient power available to provide the desired power as determined in step S3. That is, power profile processor determines whether the communications station power supply has the capacity to provide power of the desired power setting for all of the TWTAs at the communications station. If so, then the method advances to step S9, and power profile processor 32 adjusts the

power setting for the respective TWTA, and the method returns to step S2. If step S6 determines that the needed power is not available, then in step S7 power profile processor 32 determines the load priorities for the several TWTAs. Some of the outgoing signals might be of a high priority, while others are of a lower priority. In such instance, each TWTA handling a higher priority signal gets a higher load priority, and power profile processor 32 adjusts the gain of the variable gain amplifier 26 associated with that TWTA accordingly. Similarly, step S4 might determine that more power than needed is being provided to a particular TWTA and so in step S7 it will be determined that the gain of the associated variable gain amplifier 26 can be reduced.

[0018] Once the load priorities are determined in step S7, in step S8 it is determined whether with the load priorities set for the minimum power requirements of each TWTA there is sufficient power to provide the power called for by these load priorities. If so, then the method proceeds to step S9, and the power settings are adjusted in accordance with the load priorities. The method then returns to step S2. If step S8 determines that there is not sufficient power to provide for the load priorities, then the method returns to step S2 without adjusting the power.

[0019] Figure 4 is a flowchart of a first embodiment of a method of determining the desired power setting in step S3 of Figure 3. In step S3-1a the ground station receives a sent power indication, indicating the power level of the signal as sent by the communications station within satellite 10. By way of example, the communications station might send a rain fade beacon indicating

the power sent. In step S3-2a, the ground station determines the power in the received signal. From these two values, the ground station determines the propagation loss in step S3-3a. Then in step S3-4a, the ground station determines the desired power setting to give the desired received power.

[0020] Figure 5 is a flowchart of a second embodiment of a method of determining the desired power setting in step S3 of Figure 3. In step S3-1b, the ground station receives a sent power indication. In step S3-2b, the ground station determines the signal to noise ratio in the received signal. In step S3-3b the ground station determines the propagation loss from the signal to noise ratio. Then in step S3-4b, the ground station determines the desired power setting to give the desired received power.

[0021] Other techniques might also be utilized to determine the desired power setting in step S3, for example utilizing the number of uncorrected errors in the received signal or the number of errors detected in the signal. Any other appropriate measure of system performance might also be utilized, particularly one that can be mathematically related to the transmitted power from the communications station. Likewise, the received power indication or the signal to noise ratio indication as determined in step S3-2a or S3-2b might be uplinked to satellite 10, and the desire power setting determined within power profile processor 32.

[0022] The present invention thus permits improved control of the power utilized by the transmitters of a multi-transmitter communications station so as to reduce the overall power requirements. While the invention has been described

with reference to a satellite communications system, the invention is applicable to ground based communication systems as well. Although the invention has been described with reference to preferred embodiments, alterations, rerrangements, and substitutions could be made, and still the result would be within the scope of the invention.